Emerging Micronutrient Deficiencies in Soils and Crops in India and Strategies for Meeting Challenges

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INTRODUCTION

Micronutrient malnutrition is found to be an important problem affecting four billion people in the world .The problem is a threat to the nutritional security of the developing world population. Micronutrient elements, such as B, Cl, Cu, Fe, Mn, Mo and Zn are usually required in amounts less that 100 mg kg^{-1} on a dry matter basis. Nine trace elements, namely As, Co, Cu, F, Fe, Mn, Mo, Se and Zn, are associated with clinical problems in livestock. The First Green Revolution established India as one of the World's largest agricultural producers. No other country in the world has recorded such a level of success for becoming self-sufficient in food grains. Such dramatic yield increases through technology transformation could not be sustained any longer, and yields began to fall in a number of areas. It is estimated that an average increase in gross domestic product (GDP) and an annual growth of 2.1% in India has dropped to about 1.5% in current years which is less than the average increase in world population. Predictions suggest that current crop yields must be doubled by 2050 to keep pace with an increasing population through intensive cropping or cultivation on marginal lands. Thus, crops will most likely suffer from micronutrient deficiencies in more soils. In view of this, attempts are made to summarize the extent of micronutrient deficiencies in Indian soils, their influence on crop yields and micronutrient malnutrition in animal and human population as well as strategies for reducing malnutrition and ushering Green Revolution II.

ASSESSEMMENT OF MICRONUTRIENT DEFICIENCIES

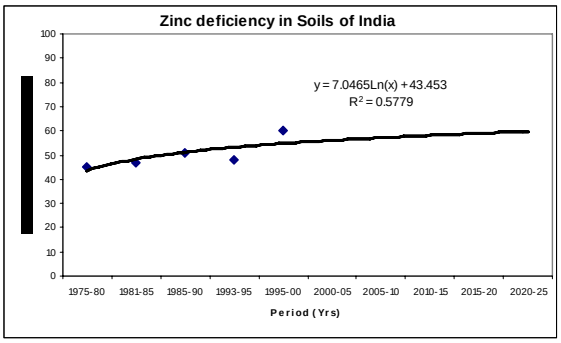
Survey studies were carried out by central and state research agencies to delineate micronutrient deficient areas and soil fertility maps for various parts of country. Surface (at 0-15 cm depth) soil and some profile samples were collected to assess the extent of micronutrient deficiencies in different soil types, administrative units, agro-ecological zones, crop production systems etc. Soil micronutrient cations, including Cu, Fe and Mn, were extracted following a DTPA method. The B status was assessed based on an analysis of about 50,000 soil samples using hot 0.15% $CaCl_2$. Available Mo was measured using the ammonium oxalate method. Representative plants, blood plasma of men, woman and animals were also sampled in different studies to assess the influence of micronutrient deficiencies in soils on crop productivity, micronutrient content of fodder and grain and the nutrition of animal and humans fed on this produce. Micronutrient contents in the extracts were determined using Atomic Absorption Spectrophotometry (AAS) and Inductively coupled Plasma-Spectrophotometery (ICP-S).

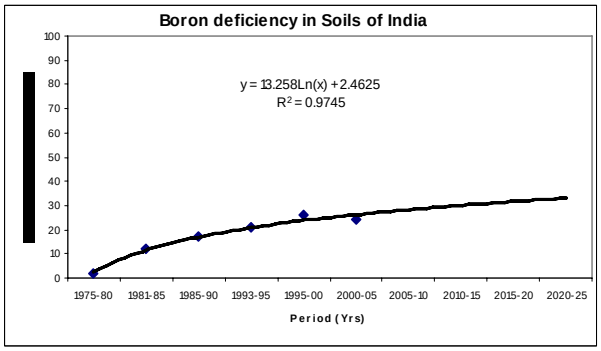
RESULTS AND DISCUSSION

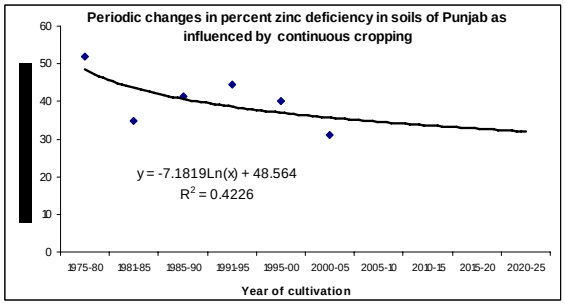
The studies reveal that Indian soils are adequate in total micronutrient contents but low in available levels. The contents varied widely with respect to soil types, cropping and management conditions. Analysis of 257,000 soil samples indicated that the average deficiency of Zn, Fe, Mn and Cu in Indian soils was 49, 12, 4 and 3 %, respectively. Similarly, the analysis of 50,000 samples showed B and Mo deficiencies in 33 and 12% of the soil samples, respectively. Among micronutrient deficiencies, Zn is the most widespread

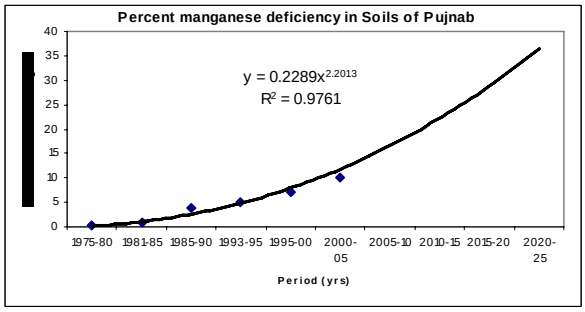
deficiency and a common problem followed by B deficiency. Most soil samples indicated an adequate supply of Cu, Fe and Mn. Acid soils showed low deficiencies of Zn (30%) and higher deficiencies of B (46%) and Mo (50%). A reverse trend was recorded in non-acidic soils. Soils of arid and semiarid regions are more affected by Zn and Fe deficiencies.

Crops showed a high response to Zn, B, Mn and Fe fertilization through soil applications or foliar sprays. Data of about 6000 experiments on cultivator fields and research farms indicated higher responses to applied Zn. On average, Zn deficiency is declining in the states of Punjab, Haryana, Uttar Pradesh and Andhra Pradesh, but in the country as a whole, Zn deficiency (%) is increasing (Fig. 1) leading to higher responses of crops to Zn fertilization. It is estimated that Zn deficiency causes 200-500 $kg^{-1}ha^{-1}year^{-1}$ loss in yield on about 70-75 million ha of cultivatable land of India. Boron deficiency (%) is also increasing in many parts of the country due to a continuous depletion of soil reserves (Fig. 2). In soils of Punjab, it is interesting to note that Zn deficiency (%) is declining (Fig. 3), whereas Mn deficiency (%) is emerging fast in wheat and other crops (Fig. 4). In contrast, multi-micronutrient deficiencies of Zn, B and Mn are increasing in Bihar leading to stagnation or a decline in productivity. This indicates that micronutrient malnutrition is becoming a complex problem varying from soil to soil and state to state.









The periodic assessment of micronutrient deficiencies revealed that the status of various soil micronutrients is declining in most parts of the country. Multi-micronutrient deficiencies are emerging fast in vast areas due to a depletion of micronutrient soil reserves as a result of continuous cropping with hybrids and supra-yielding plant types, use of micronutrient-free fertilizers, lower use of organic manures and a decline in recycling of crop residues during the Green Revolution in India. Analysis data of about 20,000 plant samples also indicated Zn, Cu, Fe and Mn deficiencies of 44, 10, 6 and 4 %, respectively, representing most of the Indian crops. This suggests that increasing multi-micronutrient deficiencies in soils and crops may not only affect crop productivity in the next 25 years, but more so create malnutrition and health problems for animals and humans that were fed forages and foods low in micronutrients from areas having an inadequate supply of micronutrients. Studies conducted in the central part of India suggest that Zn levels in blood plasma of men and women from

rural Nalgonda and Karimnagar districts of Andhra Pradesh were lower in humans fed on farm produce from Zn-deficient areas compared to Zn-adequate soils. Studies conducted in North Bihar and Gujarat indicated that Zn and Mn nutrition affected health and reproduction of cattle adversely. It is estimated that micronutrient deficiencies cause a 5 % loss of the GDP alone due to maydays lost in illness and expenditure being incurred for cure in India.

Studies showed that the application of micronutrient fertilizers can correct their deficiencies more effectively and enrich plants and seeds with micronutrients. Among different methods, soil and foliar applications are found more effective than seed treatments, root dipping etc. The integrated use of micronutrients and organic matter is the best way to ameliorate such deficiencies and to reduce malnutrition.

SUMMARY AND CONCLUSIONS

The paper summarizes the extent of micronutrient deficiencies in Indian soils and crops and their influence on soil and crop productivity and micronutrient malnutrition. The first Green revolution in India brought a grand success in achieving self-sufficiency in food production but it also caused a greater exploitation of the micronutrient soil reserves. Among micronutrients deficiencies, Zn is the most common problem in soils (48 %). Multi-micronutrient deficiencies are emerging fast in several areas and cause a decline in crop yields and total productivity and cause micronutrient malnutrition in livestock and human populations. Strategies involving the soil application of micronutrients, seed treatment, foliar sprays or use of organic manure were found to sustain an optimum yield potential and enhance the micronutrient content of seeds, forages and vegetables crops to curve micronutrient malnutrition menace and achieve nutritional security among people of India.